Could the Laws of Nature Change?*

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After reviewing several failed arguments that laws cannot change, I use the laws' special relation to counterfactuals to show how temporary laws would have to differ from eternal but time-dependent laws. Then I argue that temporary laws are impossible and that neither Lewis's nor Armstrong's analyses of law nicely accounts for the laws' immutability.

1. Introduction. The natural laws are traditionally characterized as 'eternal', 'fixed', and 'immutable'.[1] Is the laws' unchanging character a metaphysical necessity? If so, then in any possible world, there are exactly the same laws at all times (though presumably there are different laws in different possible worlds).[2] That there actually are exactly the same laws at all times is then a consequence of what it *is* for a truth to be a law of nature. On the other hand, if the laws' unchanging character is *not* a metaphysical necessity, then even if in fact there have always been and will always be exactly the same laws, this fact is metaphysically contingent.

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1. In the span of a single sentence, Spinoza (1951, 83) applied all three of these adjectives to the laws. Descartes (2000, 28–29) addressed the laws' fixity in a letter to Mersenne (April 15, 1630):

> [I]t is God who has established the laws of nature, as a King establishes laws in his kingdom. . . . You will be told that if God has established these truths, he could also change them as a King changes his laws. To which it must be replied: yes, if his will can change. But I understand them as eternal and immutable. And I judge the same of God.

2. It is standard to unpack 'p is metaphysically necessary' as 'p is true in all possible worlds' (see, e.g., Sider 2003, 186), though of course, there are many different views regarding the ontology of possible worlds and the proper interpretation of possible-worlds talk.

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To ask whether the laws of nature could change is not to ask whether a given fact *m*, which is actually a law of nature, could instead have been an accident. Rather, my question is whether it follows with metaphysical necessity, from the fact that *m* is *now* a law, that *m* always was and always will be a law. One way to judge among various proposed philosophical analyses of natural law is first to figure out whether or not the laws must be immutable and then to examine how well each proposed analysis explains why this is so. This is the project I try to pursue in this paper.

Occasionally, one encounters articles with provocative titles such as "Anything Can Change, Even an Immutable Law of Nature" (*New York Times*, August 15, 2001) and "Are the Laws of Nature Changing with Time?" (*Physics World*, April 2003). These articles generally concern whether certain physical parameters heretofore believed constant may in fact be slowly changing. Despite the sensationalistic titles of these articles, such changes need not threaten the laws' immutability. The laws at every moment may still be the same—identifying the same function of time (or of some other factor) as giving the physical parameter's value at every moment.

Likewise, in articles about cosmology or elementary particle physics, one sometimes reads that as the universe cooled after the Big Bang, symmetries were spontaneously broken, 'phase transitions' took place, and discontinuous changes occurred in the values of various physical parameters (e.g., in the strength of certain fundamental interactions, or in the masses of certain species of particle). These changes are sometimes described as involving changes in the laws of nature. Here is a typical remark:

> One usually assumes that the current laws of physics did not apply [in the period immediately following the Big Bang]. They took hold only after the density of the universe dropped below the so-called Planck density, which equals 10^{94} grams per cubic centimeter. . . . [T]he same theory may have different 'vacuum states', corresponding to different types of symmetry breaking between fundamental interactions and, as a result, to different laws of low-energy physics. (Linde 1994, 48, 55)

However, perhaps this 'change' in the laws of nature as the universe cooled and expanded is better understood as involving unchanging laws such as (to give a very simple example)

(1) Between any two electrons that have been at rest, separated by *r* centimeters, for at least r/c seconds, there is an electrostatic repulsion of *F* dynes, if the universe is no more than 10^{-10} seconds old, and *f* dynes ($f \neq F$) otherwise.

Instead of citing the universe's age, the law might instead specify the critical factor as the universe's being cooler than 3×10^{15} degrees Kelvin, for example (Weinberg 1977, 143). In that case, (1)—citing the universe's age—would be an accidental truth, not a law. Presumably, the electrostatic forces between electrons before and after the temperature threshold is crossed would then be explained by laws that do not merely specify the strengths of these particular forces in the manner of (1). Rather, laws more fundamental than any resembling (1) would explain why 3×10^{15} K is the critical temperature (for many kinds of interactions, not just for the mutual electrostatic repulsion of two electrons) and by what process there arises new behavior as a result of the universe's crossing this temperature threshold. If the 'phase transition' is properly understood in this fashion, then it does not involve a change in the laws of nature.

On the other hand, perhaps the 'phase transition' is properly understood differently, as involving

(2) Between any two electrons that have been at rest, separated by r centimeters, for at least r/c seconds, there is an electrostatic repulsion of F dynes,

holding as a law during the period before the universe is more than 10^{-10} seconds old, and

(3) Between any two electrons that have been at rest, separated by r centimeters, for at least r/c seconds, there is an electrostatic repulsion of f dynes,

holding as a law thereafter ($f \neq F$). In that case, the 'phase transition' really does involve a change in the laws. Once again, I have chosen a simple example. More realistically, the laws before the universe is 10^{-10} seconds old would include (2) as a consequence of some broader law, covering more than just the mutual electrostatic repulsion between long stationary electrons, and likewise for the new laws after the 'phase transition'.

We will have to explore how (1)'s being a law at all times (an eternal but time-dependent law) would differ from (2)'s and (3)'s each being laws at different times (temporary laws). If there is no difference, then the laws' immutability is a *trivial* matter. Having better understood the difference between these options, we will be better positioned to see which option (if either) is the proper interpretation of the posited 'phase transition'.

Of course, it is undeniable that our *beliefs* about the laws can change (and, accordingly, that we can change what we *call* 'laws'). But the possibility of these changes fails to show that the laws themselves can change, unless the laws at a given time are just those truths that at that time are widely respected as able to play certain special roles in scientific reasoning (perhaps in connection with counterfactual conditionals and scientific explanations). I shall presume that a truth's character as a law or an accident is not a reflection of whether or not scientists treat it as a law. In this respect, I accord with most of the accounts of natural law on the market today, however much they may disagree on what laws of nature are, including Lewis's (1973, 1986, 1999) best-system account, Armstrong's (1983, 1997) contingent-relations-among-universals account, and Ellis's (2001) essentialist account. I presume that a given truth's lawhood is a mind-independent feature of the world and that science aims to ascertain which truths are laws and which are not. I thus set aside views according to which we somehow (either individually or as a community of inquirers) 'project' lawhood onto certain facts in calling them laws and using them to play certain roles in science (Goodman 1983, 21), as well as views according to which the concept of a natural law is not useful for reconstructing scientific reasoning (van Fraassen 1989; Giere 1995) and views according to which the laws are not a select proper subset of the truths (Cartwright 1983; Swartz 1985).

It is sometimes held that there are laws of special sciences and that these laws were not laws until after their special subject-matter arose. For example, "The idea that Ohm's law has a timeless, transcendent existence, and has been 'out there', lying in wait, for aeons until somebody built an electric circuit is surely ludicrous" (Davies 1995, 258). An analogous argument might be made regarding any putative law of biology, law of automobile repair, law of Earth science, and so forth. I shall steer clear of this (dubious) argument by confining my attention to whether the fundamental laws of physics can change.

Some physicists have recently suggested that as the universe expanded and cooled, new fundamental forces, particles, and the laws governing them came into being:

> In a more serious vein, one could ask whether the laws of physics are intimately bound up with the evolution of the universe, influenced not only by the initial conditions, but also by the subsequent evolutionary processes themselves. . . . Is it at all possible that the generations of quarks and leptons have 'evolved' one after another in some sense, that each generation is 'born', so to speak, at the corresponding energy (or length) scale of an expanding universe, its properties being influenced, but not necessarily deterministically fixed, by what already exists? . . . So what I should mean would be that the constants like mass [e.g., the mass of each top quark, the mass of each W meson] are really dynamical quantities that were selected, with some degree of chanciness, from among other possibilities in the course of the universal evolution. (Nambu 1985, 108–109)

> The hierarchy of laws has evolved together with the evolution of the universe. The newly created laws did not exist at the beginning as laws but only as possibilities. (Thirring 1995, 132; cf. Stöltzner 1995, 50)

Of course, it is notoriously presumptuous for a philosopher to rule out some scientific theory that is "being discussed in respectable scientific fora" (as Schweber 1997, 173 says is the case of the notion that "laws of nature mutate")—to declare that the theory's truth is metaphysically impossible! On the other hand, perhaps talk of 'newly created laws' is a bad metaphysical gloss on a perfectly respectable scientific theory. I shall argue that this is the case.

In Section 2, I explain several reasons why Poincaré's argument for the laws' immutability fails. In Section 3, I argue that the laws' truth fails to ensure the laws' immutability, considering that laws may be uninstantiated and that a 'temporary law' should be required to govern only a certain period of time. In Section 4, I elaborate how laws differ from accidents in their relation to counterfactuals. I use this result in Section 5 to explain how temporary laws would differ from eternal but time-dependent laws. This leads to an argument that the laws cannot change—an argument that avoids the problems encountered by the arguments against temporary laws in Sections 2 and 3. Finally, in Section 6, I argue that neither Lewis's best-system account of laws nor Armstrong's contingent-relations-among-universals account nicely explains the laws' immutability. Rather, the laws' immutability must be written into these accounts 'by hand'. An important criterion of adequacy for any proposed metaphysical analysis of natural law should be to explain why temporary laws are impossible.

2. Poincaré's Argument for the Laws' Immutability. Nineteenth-century enthusiasm for evolution led some natural philosophers to take seriously the possibility that the laws can change over time. (As we have just seen, the same biological metaphors are still being invoked.) Responding to these proposals, Poincaré (1963) insisted that the laws cannot change. Rather, the laws entail that different regularities hold under different nomically possible conditions, and a change in those conditions should not be mistaken for a change in the laws themselves. What has changed instead "are nothing but resultants" (1963, 12) of the laws and accidental conditions; the genuine laws "remain intact" (1963, 13). Poincaré's argument for this view seems to be that any change in the putative laws must happen for some reason, and that reason must involve principles that remain unchanged in the transition, namely, the genuine laws. They remain intact "since it will be through these principles that the changes will be made" (1963, 13).[3]

The 'phase transitions' posited as occurring early in the universe's history may perhaps be understood along the lines suggested by Poincaré. The current 'laws of low-energy physics' result from the fundamental laws together with an accidental condition prevailing in our cosmic epoch: the state of the Higgs field (or of several different fields). The current 'laws of low-energy physics' were violated in the early universe because different accidental conditions prevailed then. Likewise, if the state of the Higgs field underwent some transition at 10^{-10} seconds after the Big Bang, then the laws governing that transition (e.g., specifying the chance in those conditions of the Higgs field's changing to the state that has since prevailed) are genuine laws, along with laws specifying how particle interactions depends on the state of the Higgs field—and none of them has changed.

However, Poincaré's general argument (as I understand it) fails to show that the laws cannot change. First, the argument presupposes that any alleged change in the laws must happen for some reason. But the fundamental laws are often taken to be brute facts (i.e., facts that could have been otherwise, but there is no reason why they are not otherwise). That scientific explanations come to an end with the fundamental laws is what makes them fundamental, after all. Just as the fundamental laws have no explanations, so a change in the fundamental laws would presumably have no explanation. It would simply be a brute fact that (2) is a law during one span of time and (3) is a law during another.

Second, even if Poincaré is correct in assuming that any alleged change in the laws must happen for some reason, why must the change be governed by a principle that remains unchanged in the transition? Consider an analogy. The Constitution codifies the fundamental laws of the United States. In Article Five, the Constitution specifies the procedures for its own amendment. An amendment could even amend Article Five. The ratification of such an amendment would then be governed by Article Five, yet Article Five would not remain unchanged in the transition. Likewise, a change in the natural laws could happen for a reason (i.e.,

3. Admittedly, Poincaré regarded the laws discovered by science as not wholly mind-independent features of the world. But although Poincaré's view of laws thus falls outside of the range of views I am addressing (see Section 1), his argument for the immutability of the laws discovered by science (the only sort of laws for which he thinks it meaningful to ask whether they vary *with time*) does not turn on any of his neo-Kantian views. Indeed, Poincaré's argument seems to me very similar to the argument for the laws' immutability given by Shoemaker (1998, 75, n. 8).

could be governed by the natural laws then in force) and yet the natural laws governing the change could still change along with the other laws.

Third, even if Poincaré is correct in assuming that any alleged change in a law must be governed by a principle that remains unchanged in the transition, this constraint imposes no obstacle to that principle itself changing at some other time, in accordance with some other principle that remains unchanged in that transition, and so forth infinitely far downward. None of these principles would then be immutable even if, as it happened, some of them never changed. Here I leave Poincaré's argument.

3. Are the Laws Immutable Just by Virtue of Being Truths? Suppose for the sake of *reductio* that (2) is a law for some span of time and (3) is a law thereafter. (This change in the laws may be brute or governed by some other principle; it makes no difference to the following argument.) Suppose that sometime during the latter period, there are two electrons that have been at rest, separated by *r* centimeters, for at least *r*/*c* seconds. Then, to accord with (3), these electrons must experience a mutual electrostatic repulsion of *f* dynes. But this occurrence violates (2). Since (2) is false, (2) is not a law. (Neither is [3], by an analogous argument concerning two electrons during the period when [2] is a law.) *Reductio* completed: the laws of nature cannot change.

This *reductio* presupposes that if it is ever a law that *m*, then *m* is true. That is certainly the traditional view: the contingent truths investigated by science consist of the laws and the accidents, and the "problem of law" (Goodman 1983, 17) is to identify the ground of this distinction. That is, according to the received view, lawhood equals truth plus lawlikeness, and the problem of law is to understand what makes a truth 'lawlike'. The above *reductio* aims to show that for the laws to change from (2) to (3), (2) would have to be false and so would (3). Hence, (2) would never be a law, and neither would (3), and so the genuine laws cannot change.

There are two points at which this argument should be resisted. The first objection notes that (2) can cease to be a law, and (3) can henceforward be a law, without violating the requirement that laws be truths—as long as (2) and (3) are both uninstantiated. All serious accounts of natural law recognize that there can be (and presumably are) plenty of uninstantiated laws.[4] If it is an accidental fact that no two electrons are ever at

4. Strictly speaking, Armstrong's account leaves no room for uninstantiated laws (since a universal, according to Armstrong, must be instantiated in order to exist). But Armstrong's account does allow for functional laws with uninstantiated values of the determinables. It construes functional laws as relations among second order universals, such as the property of being an electric charge property, where this second order

rest exactly r centimeters apart for r/c seconds, then (2) and (3) are both true. So during the period when (2) is a law, (3) must be an accident, and vice versa. Hence the above *reductio* fails to rule out all changes in the laws: it fails to rule out vacuous truths swapping lawlikeness for nonlawlikeness and vice versa. (Of course, fans of changing laws have something more dramatic in mind than changes confined to vacuous truths. But that this argument fails to apply to vacuous truths highlights the fact that it appeals to nothing about the laws beyond their truth. One might have expected the laws' immutability to derive somehow from whatever it is that makes them laws over and above their truth.)

The second objection accuses the *reductio* of begging the question against the laws' mutability by taking for granted that if m is ever a law, then m is true. The requirement that laws be truths is itself motivated by the presupposition that the laws cannot change. To remain open-minded about whether there can be different laws during different periods, we should demand only that if m is a law throughout some period, then the events occurring *in that period* accord with m—i.e., that, loosely speaking, m be true 'of the period' that m governs, though perhaps not true *simpliciter* (i.e., not 'true of the universe's entire history'). Of course, for m to be a law during some period, it is not enough that m be true 'of that period'; this condition fails to distinguish the period's laws from its accidents. But our present concern is limited to the 'truth' requirement; the *reductio* did not aim to exploit m's lawlikeness, but only its truth.

To put matters a bit more precisely: m is true 'of a given period' exactly when the universe's history during that period is logically consistent with m's truth. Under the revised 'truth' requirement (namely, that m is a law in a given period only if m is true of that period), (2) can cease to be a law, and (3) can henceforward be a law, even if during each period, there are electrons at rest separated by exactly r centimeters for at least r/c seconds.

4. How Do Laws Differ from Accidents? Suppose that (2) is true 'of the earlier period' in the universe's history, and that (3) is true 'of the later period'. What makes (2) a law in the former period and (3) a law in the latter? Here we must turn from considering the laws' truth to considering their 'lawlikeness'.

One of the traditional differences between laws and accidents is that laws govern not only what does happen, but also what would have happened under various unrealized circumstances. In other words, laws stand

universal is instantiated even if certain values of electric charge are not (Armstrong 1983, 113). So Armstrong's account would presumably allow for laws like (2) and (3) to be uninstantiated.

in an especially intimate relation to counterfactuals. Even if no two electrons actually find themselves having been at rest for at least r/c seconds, exactly r centimeters apart, during the period when (2) is a law, (2) is not idle. It specifies what would have happened then, had there been two such electrons: they would have experienced a mutual electrostatic repulsion of F dynes. The truth of

(4) Had two electrons been at rest and exactly r centimeters apart for at least r/c seconds at some moment when the universe is no more than 10^{-10} seconds old, then any such electrons would have experienced at that moment a mutual electrostatic repulsion of F dynes

does not contradict the truth of

(5) Had two electrons been at rest and exactly r centimeters apart for at least r/c seconds at some moment when the universe is more than 10^{-10} seconds old, then any such electrons would have experienced at that moment a mutual electrostatic repulsion of f dynes,

which (3)'s lawhood during the later period requires, just as there is no contradiction in both

> Had an electron been 5 centimeters from point P at time t, then it would at that moment have experienced an electrostatic force of F dynes

and

> Had an electron been 10 centimeters from point P at time t, then it would at that moment have experienced an electrostatic force of f dynes

($f \neq F$) being true.

Let us look more closely at the difference between laws and accidents in their relation to counterfactuals. Intuitively, once the laws of nature are fixed, there are various 'knobs' for setting the universe's initial conditions (or any system's boundary conditions), and these knobs can be turned (hypothetically!) in any fashion that is logically consistent with every m where it is a law that m. No matter to what setting the knobs are turned (counterfactually), within these generous limits, the actual laws would still have held.[5] One entertaining example of knob-turning takes

5. This intuitive picture is rejected by Lewis, for example (for discussion, see Lange 2000), and requires careful elaboration. The electron is stable, but had there been a less massive lepton possessing one unit of negative electric charge, then perhaps the electron would have been unstable (since there would have been a particle into which it could decay while conserving electric charge and lepton number). So the actual laws

place in Comins's (1993) book, *What If the Moon Didn't Exist: Voyages to Earths That Might Have Been*. An astronomer at the University of Maine, Comins devotes one chapter to explaining what the Earth would have been like had the Moon not existed (the Earth's rotation would have been much faster without the Moon's gravitational tug), another to explaining what the Earth would have been like had it been tilted like Uranus, another to what the Earth would have been like had the Sun been more massive, and so forth. Cumins takes (what we believe to be) the laws of nature and extrapolates from them to the conditions that would have existed under these various counterfactual circumstances.

Apparently, laws have greater invariance than accidents under counterfactual perturbations. Compare Reichenbach's favorite accidental generalization, that all solid gold cubes are smaller than one cubic mile (Reichenbach 1954, 10), to the law (supposing it to be one) that all solid cubes of uranium-235 are smaller than one cubic mile (in view of the laws governing nuclear chain-reactions). Had Bill Gates wanted to build a large gold cube, then (I dare say) there would have been a gold cube exceeding

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of nature (which entail the electron's stability) might not still have held, had there been a less massive lepton with one unit of negative electric charge. The existence of such a lepton species (call them 'nuons') is logically consistent with the laws of nature ('all electrons are . . . ', 'all protons are . . .', etc.) *unless* one of the laws stipulates that all particles are either electrons or protons or . . . (a list that does not include nuons). So our intuitive picture suggests the existence of such a 'closure law'. Intuitively, the laws of nature determine what knobs exist to be turned, and since the natural laws make no provision for nuons, there is no knob for adjusting the number of nuons in the universe's history and thereby undermining the electron's stability. Here is another example along the same lines. Suppose it is a natural law that whenever a muon decays, it turns into an electron and an electron-type neutrino. But 'every decaying muon turns into an electron and a electron-type neutrino' (call this generalization '*L*') is logically consistent with every muon-decay event having (say) a 20% chance of yielding an electron and a muon-type neutrino (and an 80% chance of yielding an electron and an electron-type neutrino). With these probabilities holding, *L* could still hold, although it would be an accident, analogous to a coin that is biased 80% in favor of heads coincidentally landing heads each time it is tossed. Indeed, had these probabilities obtained, *L* would probably not still have held; the string of heads would probably break. Yet since these probabilities are logically consistent with *L*, we seem to have here a counterfactual supposition with which the laws are logically consistent but under which the laws would not all still have held. Once again, however, the intuition is that the laws would still have held under any counterfactual antecedent that posits some distribution of the properties governed by the laws. The counterfactual antecedent should not posit a new kind of property-instance for which the laws leave no room, such as a particle's being a nuon or a statistical property (e.g., a muon decay's having a 20% chance of yielding an electron and a muon-type neutrino) where the relevant laws are deterministic. There are no knobs for adjusting the distribution of properties such as these. The laws of nature must include many closure laws—not only 'there are no nuons', but also 'no muon decay has a chance of yielding anything but an electron and an electron-type neutrino' (see Lange 2000, 284–285).

a cubic mile. But even if Bill Gates had wanted to build a large cube of uranium-235, all U-235 cubes would still have been smaller than a cubic mile.[6] Indeed, the laws are also invariant under nested counterfactual suppositions. For example, even if Bill Gates had had access to 23rd-century technology, he would have failed to build a large U-235 cube, had he wanted to build one.[7] The laws would still have been true, had p been the case, for any p that is 'nomically possible' (i.e., logically consistent with all of the laws), and likewise the laws are invariant under nested counterfactual suppositions each of which expresses a nomic possibility. But for each accident m, there is some such p under which it is not the case that m would still have held. I shall term this idea 'Nomic Preservation' (NP):

> **NP.** For any m that is not a logical necessity (understood broadly so as to include necessities that are conceptual, mathematical, etc.), it is a law that m if and only if for any counterfactual suppositions q, r, and so on, the subjunctive conditionals $q \mathrel{\Box\!\!\rightarrow} m$ ['had q been the case, then m would (still) have been the case'], $r \mathrel{\Box\!\!\rightarrow} (q \mathrel{\Box\!\!\rightarrow} m)$, and so on, are all true as long as q is nomically possible (i.e., logically consistent with every m where it is a law that m), r is nomically possible, and so on.

(I shall reserve lowercase letters for sentences purporting to state facts that are governed by laws but not facts about what's doing the governing. So 'q' may stand for 'all emeralds are green' or 'all solid gold cubes are smaller than a cubic mile' but not for 'it is a law that all emeralds are green' or 'it is an accident that all solid gold cubes are smaller than a cubic mile'.) Principles roughly like NP have been defended by Chisholm (1946), Strawson (1952), Mackie (1962), Pollock (1976), Jackson (1977), Goodman (1983), Bennett (1984), Horwich (1987), Carroll (1994), and many others.[8]

6. OK, even Bill Gates could not afford a cubic *mile* of gold. But he could afford a cubic meter of gold—or a cubic mile of good-quality Timothy hay. But set these details aside for the sake of a vivid example.

7. The nested counterfactual $p \mathrel{\Box\!\!\rightarrow} (q \mathrel{\Box\!\!\rightarrow} r)$ is not logically equivalent to $(p\&q) \mathrel{\Box\!\!\rightarrow} r)$. For example, suppose we run a race, I try hard and win, and I boast that I would always win if I tried: had you won, then had I tried, I would have won. This nested counterfactual is plainly not logically equivalent to the false 'had you won the race and I tried, then I would have won'.

8. In stating NP, I ignore any complications that might result from distinguishing laws of nature from contingent logical consequences of the laws that are not themselves laws. That is, in considering counterfactual suppositions that are logically consistent with every m where it is a law that m, I presume that m is a law if m is contingent and follows logically from $h\&j\&\cdots\&k$, where it is a law that h, it is a law that j, . . . and it is a law that k.

Of course, the truth-values of counterfactual conditionals are notoriously context-sensitive. For example, in a conversational context where we are bemoaning the paucity of quality pitching in the Major Leagues today, the counterfactual 'had Hank Aaron been playing today, he would have hit 60 home runs in a season' expresses a truth, whereas this counterfactual conditional expresses a falsehood in a context where other facts (such as Aaron's date of birth) are also salient, and accordingly a truth is expressed by 'had Hammerin' Hank been playing today, he would still have managed to slug 10 homers in a season, despite being in his 70s'. I presume that the laws of nature are the same in all conversational contexts. Since NP purports to capture the *logical* relation between laws and counterfactuals, and logic is not context-sensitive, I understand NP as asserting that if m is a law, then $q \mathrel{\Box\!\!\rightarrow} m$ and so forth are true in all conversational contexts.[9]

NP permits there to be *some* nomically possible counterfactual suppositions q under which a given accident is invariant. Admittedly, all gold cubes would still have been smaller than a cubic mile even if I had worn a different shirt today. NP insists only that there be some nomically possible counterfactual supposition q under which the gold-cube generalization would not still have held. Plainly, there is at least one such supposition: Had there been a solid gold cube larger than a cubic mile! Of course, this q can be used with NP to show that Reichenbach's generalization does not state a law only because this q is nomically possible—that is, only because Reichenbach's generalization does not state a law!

This example highlights the circularity that threatens if we use the notion of consistency with the laws to delimit the range of counterfactual perturbations under which a fact must be invariant in order for it to qualify as a law. We would then be using the laws to pick out the range of counterfactual suppositions that, in turn, are used to pick out the laws. To understand what laws of nature are, we need a means of distinguishing the laws from the accidents that does not presuppose that this distinction has already somehow been drawn.

9. The context-sensitivity of counterfactual conditionals is fully recognized by advocates of principles like NP. In Lange 2000 and Lange 2007, I give a fuller account of the way that principles like NP must be crafted to respect the context-sensitivity of counterfactuals. Here I omit these details (since they would not affect my arguments) as well as my defense of NP against the suspicion that there are at least some conversational contexts in which a law fails to be invariant under a counterfactual supposition that is logically consistent with all of the laws. Seelau et al. (1995, 66) offer a psychological perspective on the way that, despite context-sensitivity, "counterfactual thoughts are restricted to those that are plausible given the natural laws operating in the world."

A solution to this problem can be found.[10] The problem arose from NP's invoking a range of counterfactual suppositions (namely, every nomically possible *q*) that has been designed expressly to suit the laws. What if we extend the same courtesy to a set containing accidents, allowing it to pick out a range of counterfactual suppositions especially convenient to itself: those suppositions that are logically consistent with that set? Take, for example, a logically closed set of truths *m* (i.e., a set containing every logical consequence *m* of its members) that includes the fact that all gold cubes are smaller than a cubic mile. The set's members would not all still have been true had Bill Gates wanted to build a large gold cube. So for the set's members all to be invariant under every counterfactual supposition that is logically consistent with them (taken all together), the set must contain the fact that Bill Gates never wants to build a large gold cube; the counterfactual supposition that he wants to do so is then logically inconsistent with a member of the set. However, presumably had Melinda Gates (Bill's wife) wanted a large gold cube, then Bill would have wanted one built. So having included the fact that Bill Gates never wants to build a large gold cube, the set must also include the fact that Melinda Gates never wants one, in order for all of the set's members still to have been true under any counterfactual supposition with which the set is logically consistent.

Such a set must be very inclusive. Suppose, for example, that the set omits the accident that all of the apples on my tree are ripe. Here is a counterfactual supposition that is logically consistent with the set: had either some gold cube exceeded one cubic mile or some apple on my tree not been ripe. Under this counterfactual supposition, there is no reason why the generalization about gold cubes (which is in the set) should take priority in every conversational context over the apple generalization (which we have supposed not to be in the set). So it is not the case that the gold-cube generalization is preserved (in every conversational context) under this counterfactual supposition. Hence, the set must also include the apple generalization if the set is to be invariant under every counterfactual supposition that is logically consistent with it. The upshot is that if a logically closed set of truths includes an accident, then it must include every accident if it is to be invariant under every counterfactual supposition that is logically consistent with it.

But according to NP, the set of laws possesses exactly this kind of invariance. We can now specify (without circularity) the laws' distinctive relation to counterfactuals. Take a logically closed set Γ of truths that is

10. Lange (2000) contains more elaborate argument for the following account.

neither the empty set nor the set of all truths m.[11] Consider those counterfactual suppositions with which Γ is logically consistent. Call the set 'stable' exactly when the set's members would all still have held, under every such counterfactual supposition (whatever the context)—indeed, no matter how many such suppositions are nested. More precisely,

> Γ is 'stable' exactly when for any member m of Γ and any claims q, r, s, . . . , each of which is logically consistent with Γ (e.g., $\Gamma \cup \{q\}$ is logically consistent), the subjunctive conditionals (which are counterfactuals if q, r, s, . . . , are false)
>
> $q \mathbin{\Box\!\!\rightarrow} m$,
>
> $r \mathbin{\Box\!\!\rightarrow} (q \mathbin{\Box\!\!\rightarrow} m)$,
>
> $s \mathbin{\Box\!\!\rightarrow} (r \mathbin{\Box\!\!\rightarrow} (q \mathbin{\Box\!\!\rightarrow} m))$, and so on,
>
> are true in any context.

Then m is a law exactly when m is not a logical necessity and belongs to a set that is stable.[12]

Since 'stability' is not defined in terms of law (but rather allows each set to pick out for itself the range of counterfactual suppositions under which its invariance is to be assessed), we have here a noncircular way of drawing a sharp distinction between laws and accidents. On this view, what makes the laws special, as far as their range of invariance is concerned, is that they form a stable set: *collectively*, taken as *a set*, the laws are as resilient as they could logically possibly be. All of the laws would still have held under *every* counterfactual supposition under which they *could* all still have held—every supposition with which they are collectively logically consistent. No set containing an accident can make that boast (except for the set of all truths m, for which the boast is trivial: there are *no* counterfactual suppositions p with which all such truths together are logically consistent). A stable set is *maximally* resilient under counterfac-

11. Had I not excluded these two sets, then they would have *trivially* qualified as 'stable' by the upcoming definition (if the widely accepted principle of counterfactual reasoning known as 'Centering' holds). I want to focus on nontrivial stability, since belonging to a nontrivially stable set is (I argue) associated with being a law and possessing necessity of some variety.

12. Even if there is more than one stable set, it suffices for m to belong to at least one stable set. In Lange 2000, I show that for any two stable sets, one must be a proper subset of the other. The laws may form a hierarchy, as in Newtonian physics, where the laws of motion form a more exclusive stratum of law, and the force laws join the laws of motion in forming a more inclusive stratum. (Classically, had the electromagnetic force been stronger, the second law of motion would still have held. Classical physicists used the second law of motion to investigate what would have happened had various hypothetical force laws held. See, e.g., Airy 1830.)

tual perturbations; it has as much invariance under counterfactual suppositions as it could logically possibly have.

Here, it seems, we have identified what it is about the laws in virtue of which they possess a certain kind of *necessity* despite being contingent truths. Intuitively, 'necessity' is an especially strong sort of persistence under counterfactual perturbations. But not all facts that would still have held, under even a wide range of counterfactual perturbations, qualify as 'necessary'. Possessing some variety of 'necessity' is supposed to be *qualitatively* different from merely being invariant under a wide range of counterfactual suppositions. Because the set of laws is maximally resilient—as resilient as it could logically possibly be—there is a species of necessity that all and only its members possess. No variety of necessity is possessed by an accident, even by one that would still have held under many counterfactual suppositions.

The laws' stability thus accounts not only for the sharp distinction between laws and accidents, but also for the laws' necessity. (Presumably, the laws' necessity is, in turn, associated with the laws' distinctive explanatory power.) Let us now see how the laws' stability bears upon the possibility of (2)'s holding as a law for the universe's first 10^{-10} seconds and (3)'s holding as a law thereafter.

5. Why the Laws Are Immutable. The above definition of 'stability' took a stable set as consisting exclusively of truths. But as we saw earlier, this stipulation begs the question against the laws' mutability if we take the laws to form a stable set. Accordingly, let us try to be more accommodating to the possibility of temporary laws by defining 'stability for a given period of time' and then identifying the laws during some period with the members of a set that is stable for that period. Take a logically closed set Γ of claims m, where each m is 'true of that period' (as I defined this notion earlier) and where Γ is neither the empty set nor the set of all claims m that are true of that period. Now call such a set 'stable for that period' exactly when its members exhibit the invariance under counterfactual suppositions that in the previous section we identified as distinguishing laws from accidents—that is, exactly when all of the conditionals demanded by the definition of "stability" are true in any context. Does a connection between lawhood during some period and stability for that period permit the laws to be different in different periods?

(It may well strike you that once we have allowed m's that are not true, but merely true of the given period, to be eligible for membership in a set that is stable for that period, then we should also drop the requirement that the members of such a set be invariant under all of these counterfactual suppositions in order for the set to qualify as stable for that period. Rather, we should restrict the counterfactual suppositions to those that pertain exclusively to the given period. Shortly, I will entertain this proposal for lowering the bar further.)

Suppose that (2) is a law when the universe is no more than 10^{-10} seconds old. Then the counterfactual conditional (4) must be true; (4)'s truth is part of what makes a certain set containing (2) qualify as stable for that period.[13] Suppose that 10^{-10} seconds after the Big Bang, (3) replaces (2) as a law. Hence, the counterfactual conditional (5) must be true; (5)'s truth is part of what makes a certain set containing (3) qualify as stable for the period when the universe is more than 10^{-10} seconds old. However, here is another counterfactual whose truth is required in order for that set containing (2) to count as stable for the pre-10^{-10}-second period:

(6) Had two electrons been at rest and exactly r centimeters apart for at least r/c seconds at some moment when the universe is *more* than 10^{-10} seconds old, then any such electrons would have experienced at that moment a mutual electrostatic repulsion of F dynes.

After all, (6)'s counterfactual antecedent q is (I presume) also logically consistent with every member m of the set containing (2) that is stable for the earlier period. But (5) and (6) cannot both be true![14]

We have here an argument that the laws cannot change, since the counterfactuals required for (2)'s lawhood during the earlier period conflict with the counterfactuals required for (3)'s lawhood during the later period. This argument is not vulnerable to the two objections lodged against the *reductio* considered in section 3. By dealing with counterfactuals, the above argument permits (2) and (3) to be uninstantiated, voiding the first objection. And the above argument does not begin by presupposing that m is a law during a given period only if m is true *simpliciter*; in order for m to be eligible for membership in a set that is stable 'for that period', m need merely be true 'of that period'. Nevertheless, even after making all of these accommodations to leave room for the laws to change, the above argument shows that the laws in a given period must be laws forever. This conclusion results not from the requirement that such a law be 'true

13. I assume throughout that (4)'s antecedent q is logically consistent with the relevant stable set, and likewise in my other examples.

14. You may be tempted to say that under the supposition that the laws change, (5) is true throughout the earlier period and (6) is true thereafter, since the laws supporting them are laws during different periods. But it is no more possible for (5) (or [6]) to be true at one time and false at another than it is for 'At 6 a.m. on June 21, 2005, Smith is 6 feet tall' to be so. Of course, the counterfactual 'Had the match *now* been struck, it would have lit' might be true when uttered at one moment and false when uttered at another (say, before and after the match was moistened). But unlike the antecedent of the match counterfactual, the antecedents of (5) and (6) contain no indexical.

of that period'. Rather, the laws' immutability follows from their 'law-likeness' as elaborated in terms of their stability (at least for that period).[15]

We are now better positioned to recognize how (1)'s being a law at all times (an eternal but time-dependent law) would differ from (2)'s and (3)'s each being laws at different times (temporary laws). (Recall that some physicists have recently floated the theory that new laws can kick in at a later moment and that these 'newly created laws did not exist at the beginning as laws'. Such remarks seem intended to distinguish the theory under consideration from a theory with eternal but time-dependent laws.) If the laws must form a stable set, then for (1) to be a law at all times, (4) and (5) must be true, but (6) does not need to be true, so there is no contradiction. In contrast, if (2) is a law during the earlier period in the universe's history and the laws of that period must form a set that is stable for that period, then (4) and (6) must be true, which conflicts with the counterfactuals required for (3) to be a law during the later period. In short, if (2) is a law in the earlier period but (3) is not, then various counterfactuals must hold that do not reflect (3)—and thereby differ from the counterfactuals that must hold if (1) is always a law.

There is another way to argue for the laws' immutability by appealing to the connection between lawhood during a period and stability for that period. Suppose m is a member of Γ, a set that is stable *simpliciter*, and q, r, s, . . . , are each logically consistent with Γ. Then $q \mathrel{\Box\!\!\rightarrow} m$, $q \mathrel{\Box\!\!\rightarrow} (r \mathrel{\Box\!\!\rightarrow} m)$, $q \mathrel{\Box\!\!\rightarrow} (s \mathrel{\Box\!\!\rightarrow} m)$, $q \mathrel{\Box\!\!\rightarrow} (r \mathrel{\Box\!\!\rightarrow} (s \mathrel{\Box\!\!\rightarrow} m))$, and so on, are all true. So in the closest q-world, m is true and these conditionals hold: $r \mathrel{\Box\!\!\rightarrow} m$, $s \mathrel{\Box\!\!\rightarrow} m$, $r \mathrel{\Box\!\!\rightarrow} (s \mathrel{\Box\!\!\rightarrow} m)$, and so on. And that's just what's needed for Γ to be stable *simpliciter* in the closest q-world.

If q is false, then this argument shows that the laws would still have been laws, had q been the case—taking the members of a set that is stable *simpliciter* to be laws, as we discussed in the previous section. We thereby save a powerful intuition: that had Jones missed his bus to work this morning, then the actual laws of nature would still have been laws—and so Jones would not have gotten to work on time had Jones (having missed his bus) simply clicked his heels and made a wish to get to work. (That was a nested counterfactual that just went by.)

Now let us run the same sort of argument, but this time let us begin by supposing not that Γ is stable *simpliciter*, but merely that Γ is stable

15. I could have argued instead that if (2) is a law in a given period, then since (2) must belong to a set that is stable for that period, the subjunctive conditional 'were squares four-sided, then (2)' is true, and so (since squares actually *are* four-sided) (2) is true—not merely true of that period. But (unlike the argument that I just gave in the main text) this argument fails to show that (2) is a *law* forever, though it does preclude (3)'s being an instantiated law during some period.

for a given period. Suppose also that q is true, so the actual world is the closest q-world. Then by the above argument, Γ is stable *simpliciter*, not merely for a given period. (For example, that q is true and the subjunctive conditional $q \,\Box\!\!\rightarrow m$ is true entails that m is true *simpliciter*, not merely true of the given period.) So Γ's members are laws forever, not merely during the given period. The laws are immutable.

By this argument, if Γ consists of all of the laws during a given period, then Γ's members are laws forever. This reasoning does not merely require all of Γ's members to be laws during a later period. It also prohibits some other claim m that is logically consistent with each of Γ's members, but not a law during the given period, from being a law (along with Γ's members) during a later period—coinciding with the advent of new 'generations' of particles. If set Σ (containing m) contains all and only the laws during a later period, then by the argument that we have just rehearsed, Σ's members (including m) must also have been laws during the earlier period.

It might well be objected that despite lowering the bar from stability *simpliciter* to stability for a given period, I have not been sufficiently hospitable to the possibility of the laws' changing. It turned out that for Γ to be stable for a given period, the very same conditionals must be true as for Γ to be stable *simpliciter*. As we have just seen, this requirement demands that the laws during a given period be laws forever—even though I did not begin by stipulating that the laws during a given period must be true *simpliciter*, merely that they must be true of that period. Accordingly, it might be suggested (as I foreshadowed near the start of this section) that we should relax the requirements that a set Γ (of claims true of a given period) must satisfy to qualify as 'stable for that period'. Let us now say that the only subjunctive conditionals $q \,\Box\!\!\rightarrow m$, $q \,\Box\!\!\rightarrow (r \,\Box\!\!\rightarrow m)$, . . . that must be true (in any context) are those where q, r, . . . each concerns exclusively the given period and where m, a logical consequence of Γ, concerns exclusively the given period. (We might say that q concerns exclusively the given period—say, when the universe is no more than 10^{-10} seconds old—if and only if there is no possible world where q is false but q is 'true of the given period'. In other words, q concerns exclusively a given period exactly when, necessarily, q is true if the universe's history during that period is logically consistent with q.) If lawhood during a given period is connected to this relaxed sense of stability for that period, then—it might be suggested—(2)'s lawhood for the period when the universe is no more than 10^{-10} seconds old does *not* demand that (6) be true, merely that (4) be true. Hence, the earlier argument for the laws' immutability is stopped.

However, even if there is a well defined sense of q's concerning exclusively a given period, as in (4)'s antecedent exclusively concerning the period when the universe is no more than 10^{-10} seconds old, what *is* the period during which (2) is a law? It is supposed to be the period when the universe is no more than 10^{-10} seconds old. But let us suppose that this is also exactly the period when the universe's temperature is not below 3×10^{15} K. (For the sake of argument, I assume that it is an accident that the temperature is below 3×10^{15} K exactly when the universe is older than 10^{-10} seconds.) So if (2)'s lawhood during this period is connected to (2)'s belonging to a set that is stable for that period (in the above, relaxed sense), then which counterfactual's truth does (2)'s lawhood demand, (7)'s or (8)'s?

(7) Had two electrons been at rest and exactly *r* centimeters apart for at least *r*/*c* seconds at some moment when the universe is no more than 10^{-10} seconds old and is *below* 3×10^{15} K, then any such electrons would have experienced at that moment a mutual electrostatic repulsion of *F* dynes.

(8) Had two electrons been at rest and exactly *r* centimeters apart for at least *r*/*c* seconds at some moment when the universe is not below 3×10^{15} K and is *more* than 10^{-10} seconds old, then any such electrons would have experienced at that moment a mutual electrostatic repulsion of *F* dynes.

There is no answer until there is a privileged way of picking out the period during which (2) is supposedly a law. But for there to be such a privileged way, something must privilege it. However, the obvious candidate is a law. Perhaps, for example, (2)'s lawhood is set to expire when the universe's age exceeds 10^{-10} seconds, and this moment just happens to be when the universe's temperature falls below 3×10^{15} K. But in that case, (1) is the genuine law; the laws never really change; (2) was never a genuine law.[16]

Here is another way to put the same point. Suppose we specify the period during which (2) is supposed to be a law as the period before the universe's age exceeds 10^{-10} seconds. In other words, suppose that counterfactuals like (7) are true whereas those like (8) are false, so that (2) belongs to a set that is 'stable for the period before the universe's age exceeds 10^{-10} seconds' (in the above, relaxed sense)—and (3) likewise belongs to a set that is (in the relaxed sense) stable for the period thereafter. Then the counterfactuals whose truth makes these sets stable for those periods follow from the counterfactuals whose truth makes a set containing (1) stable *simpliciter*. So on this interpretation of the laws 'changing', (2)'s being a law during the pre-10^{-10}-second period and (3)'s being

16. Of course, since (1) is a law and logical consequences of laws are laws (see note 8), it is a law that (2) is true of the period before the universe turns 10^{-10} seconds old.

a law thereafter adds nothing, as far as which subjunctive conditionals hold is concerned, to (1)'s being a law forever. I suggest that the temporary laws add nothing *at all* here. Once it is stipulated that the relevant period is to be designated as the period before the universe's age exceeds 10^{-10} seconds, the laws 'changing' from (2) to (3) at the close of that period is nothing but (1)'s being a law throughout the universe's history. We have here not temporary laws, but rather an eternal (albeit time-dependent) law.[17]

6. Consequences for Metaphysical Analyses of Law. We have found no interesting sense in which the laws can change. I conclude that the laws are immutable. From this result, what morals can we draw regarding what it *is* to be a law of nature?

Consider first Lewis's Humean 'best system' account of the laws as the members of the deductive system of truths having the best combination of simplicity and informativeness regarding the entire history of instantiations of all properties of an elite sort: the natural, categorical, non-haecceitistic properties possessed intrinsically by spatiotemporal points or occupants thereof (Lewis 1973, 73; 1986; 1999). On Lewis's account, the laws are immutable, since the laws at each moment are fixed in the same way by the same thing: the universe's complete history of elite-property instantiations.

However, Lewis's account entails the laws' immutability only because

17. I have just argued that if we try to have (3)'s lawhood set by law to kick in when the universe's age exceeds 10^{-10} seconds, then (1) is an eternal law and (3) is not a temporary law. However, what if (3)'s lawhood is not predetermined to kick in, but rather results from an indeterministic process? For example, suppose it is a law that when the universe is exactly 10^{-10} seconds old, there is a 50% chance that (3) will thenceforth be a law and a 50% chance that (2) will thenceforth be a law. (The statistical law we have just posited would be a meta-law: a law governing other laws. See Lange 2007 for more on meta-laws.) If by chance (3) turns out thenceforth to be a law, then it will apparently be a temporary law; before the universe is 10^{-10} seconds old, it is not a law that (3) holds after the universe is 10^{-10} seconds old, since before the universe is 10^{-10} seconds old, there is some chance that (2) holds and (3) does not after the universe is 10^{-10} seconds old.

However, (3) cannot achieve temporary lawhood by this route if its temporary lawhood would require its belonging to a set Γ that is stable (in the above, relaxed sense) for the period after the universe's age exceeds 10^{-10} seconds. Suppose that q exclusively concerns the period after the universe is 10^{-10} seconds old, and although q is logically consistent with (3) (and indeed, let us presume, with Γ), q is much more likely if (2) is true of the given period than if (3) is true of that period. Then (at least in certain contexts, where backtracking is permitted) had q obtained, then the indeterministic process might well have had a different outcome and so (3) might well not have been true of the given period. Therefore, (3) does not belong to a set that is stable (in the relaxed sense) for the period after the universe is 10^{-10} seconds old and so is not a temporary law.

a certain parameter in the account has been set to 'the universe's entire history'. That parameter could be set differently. For example, there is a deductive system of truths having the best combination of simplicity and informativeness regarding the elite-property instantiations during a given period. I see no grounds on which Lewis's account could object to deeming the members of that system to be the laws during that period.

For instance, Lewis's account might be motivated roughly as follows (following Beebee 2000, 547):

> You: Describe the universe please, Lord.
>
> God: I'm so glad you asked. Right now, there's a particle in state Ψ_1 and another particle in state Ψ_2 and I'll get to the other particles in a moment, but in exactly 150 million years and 3 seconds, there will be a particle in state Ψ_3 and another particle in state Ψ_4 and . . .
>
> You (checking watch): Lord, I have to hold office hours in a few minutes.
>
> God: All right, I'll cater to your schedule by describing the universe in the manner that is as brief and informative as it is possible simultaneously to be. This is just to tell you the laws of nature.
>
> You: Do tell . . .

The trouble is that you might just as well have begun the conversation by asking God to tell you about the goings on during some particular period of the universe's history. If what God ultimately tells you in the first imaginary conversation merits being deemed 'the natural laws', then by the same token, what God ultimately tells you in the second imaginary conversation merits being deemed 'the laws during the given period'.

The deductive system of truths having the best combination of simplicity and informativeness regarding the actual universe's first 10^{-10} seconds is presumably rather different from the best system for the 10^{-10}-second period beginning when you reach the end of this sentence. Indeed, if the laws of a given period are just the members of the best system for that period, then the laws of March 2005 could in principle differ even from the laws of March 10, 2005.

Such a result is avoided, and the laws are immutable, only if we restrict our attention to the best system for the universe's entire history. But the rest of Lewis's account does not demand this restriction; the notion of 'the best system for the period $[t_1, t_2]$' is perfectly coherent (if the notion of 'the best system for the universe's entire history' is coherent). To fix the relevant period as the universe's entire history is artificial; it must be inserted 'by hand'. If the laws are immutable, then Lewis's account contains an extra degree of freedom—a surplus adjustable parameter, which must be set in an ad hoc manner.[18]

Non-Humean account of natural law would seem better able to explain why the laws are immutable. For example, suppose that laws are contingent relations (of a certain sort) among universals, as Armstrong (1983, 1997), among others, has maintained. Since universals stand outside of the ebb and flow of particular events,[19] so likewise (it seems) does their standing in certain relations; those facts cannot change. Armstrong (1983, 79–80, 100) argues that since a property is identical in all of its instantiations, any relation among universals must hold omnitemporally.

However, Armstrong recently says that although he used to argue that no change in the contingent relations among universals is possible, he now tends to think otherwise:

> Why may it not be that F has the nomic relation [to] G at one time, but later, since the connection is contingent, this relation lapses, perhaps being succeeded by F's being related to H? . . . It seems that I have to allow that contingent relations between universals can change. (1997, 257–258)

Armstrong's thought seems to be that although a property remains identical in all of its instantiations, a universal need not stand in the same nomic-necessitation relations at all times for it to be the selfsame universal. If that is correct, then (since, I have argued, laws cannot change) laws cannot be 'nomic necessitation' relations among universals.

I am inclined to think that the analysis of laws in terms of contingent 'nomic necessitation' relations among universals ultimately fails to specify whether or not the laws can change. The notion of a nomic necessitation relation is left underdescribed. Of course, the account could be made simply to stipulate that the nomic necessitation relations holding among

18. Of course, my argument that the laws must be immutable depended crucially on certain views of the laws' relation to counterfactuals (notably NP and the laws' stability) that Lewis famously rejects. So although my initial aim was *first* to figure out whether or not the laws must be immutable, and only *then* to test various proposed philosophical analyses of law by examining how well they explain why this is so, my argument that the laws must be immutable ended up not proceeding from neutral ground, but rather begged the question against Lewis's account. Neutral ground is hard to find hereabouts. Nevertheless, I have identified an adjustable parameter in Lewis's account; although Lewis has adjusted it so that his account entails that the laws must be immutable, their immutability is dispensable rather than integral to the account (in the absence of some further motivation—perhaps deriving from the laws' systematizing function—for setting the parameter as Lewis does).

19. Although, Armstrong says, a universal cannot exist uninstantiated (as came up in note 4).

universals (such as F-ness nomically necessitating G-ness) are such as to support exactly the counterfactuals that are required for the corresponding set of truths (containing ‘all Fs are G’) to qualify as stable. But while this stipulation would enable the analysis of law to entail the laws’ immutability, this stipulation would strike me as building into the account precisely what the account needs to explain.[20] Rather than getting the right answer by some *ad hoc* fine tuning added loosely to the core proposal, the account should offer an independent picture of what it is for universals to stand in relations of nomic necessitation, and from this picture, the laws’ immutability should follow naturally and inevitably.[21]

REFERENCES

Airy, G. B. (1830), “On Certain Conditions under Which a Perpetual Motion Is Possible”, *Transactions of the Cambridge Philosophical Society* 3: 369–372.

Armstrong, David (1983), *What Is a Law of Nature?* Cambridge: Cambridge University Press.

——— (1997), *A World of States of Affairs*. Cambridge: Cambridge University Press.

Beebee, Helen (2000), “The Non-governing Conception of Laws of Nature”, *Philosophy and Phenomenological Research* 61: 571–593.

Bennett, Jonathan (1984), “Counterfactuals and Temporal Direction”, *Philosophical Review* 93: 57–91.

Carroll, John (1994), *Laws of Nature*. Cambridge: Cambridge University Press.

Cartwright, Nancy (1983), *How the Laws of Physics Lie*. Oxford: Clarendon.

Chisholm, Roderick (1946), “The Contrary-to-Fact Conditional”, *Mind* 55: 289–307.

Comins, Neil F. (1993), *What If the Moon Didn’t Exist? Voyages to Earths That Might Have Been*. New York: Harper Collins.

Davies, Paul (1995), “Algorithmic Compressibility, Fundamental and Phenomenological Laws”, in Friedel Weinert (ed.), *Laws of Nature: Essays on the Philosophical, Scientific, and Historical Dimensions*. Berlin: de Gruyter, 248–267.

Descartes, Rene (2000), *Philosophical Essays and Correspondence*. Edited by Roger Ariew. Indianapolis: Hackett.

Ellis, Brian (2001), *Scientific Essentialism*. Cambridge: Cambridge University Press.

——— (2005), “Marc Lange on Essentialism”, *Australasian Journal of Philosophy* 83: 75–79.

Giere, Ronald (1995), “The Skeptical Perspective: Science without Laws of Nature”, in

20. Having the advantages of theft over honest toil is a common charge against Armstrong’s account (Lewis 1986, xii; Mellor 1991, 168).

21. Ellis (2001) and others have suggested that natural laws are metaphysically necessary; the laws in which a causal power or natural kind figures must be laws in any world in which that power or kind exists. Moreover, a world’s essence fixes what kinds and powers exist there (Ellis 2001, 275–276). Therefore, it seems to me, a world’s laws are unchangeable according to this analysis of natural law. (Perhaps a fan of this view of laws might leave room for changing laws by allowing a world’s essence to specify certain kinds as natural before a given moment and other kinds as natural thereafter. However, some of the arguments given for this view of laws presuppose that laws must be immutable—see Shoemaker 1998.) In Lange 2004, I critically examine this proposal’s account of why laws support the counterfactuals they do; Ellis (2005) and Handfield (2005) have replied, and I have replied to them (Lange 2005).

Friedel Weinert (ed.), *Laws of Nature: Essays on the Philosophical, Scientific, and Historical Dimensions*. Berlin: de Gruyter, 120–138.
Goodman, Nelson (1983), *Fact, Fiction and Forecast*. Cambridge, MA: Harvard University Press.
Handfield, Toby (2005), "Lange on Essentialism, Counterfactuals, and Explanation", *Australasian Journal of Philosophy* 83: 81–85.
Horwich, Paul (1987), *Asymmetries in Time*. Cambridge, MA: MIT Press.
Jackson, Frank (1977), "A Causal Theory of Counterfactuals", *Australasian Journal of Philosophy* 55: 3–21.
Lange, Marc (2000), *Natural Laws in Scientific Practice*. Oxford: Oxford University Press.
——— (2004), "A Note on Scientific Essentialism, Laws of Nature, and Counterfactual Conditionals", *Australasian Journal of Philosophy* 82: 227–241.
——— (2005), "A Reply to Ellis and to Handfield on Essentialism, Laws, and Counterfactuals", *Australasian Journal of Philosophy* 83: 581–588.
——— (2007), "Laws and Meta-laws of Nature", *Harvard Review of Philosophy* 15: 21–36.
Lewis, David (1973), *Counterfactuals*. Oxford: Blackwell.
——— (1986), "A Subjectivist's Guide to Objective Chance", in *Philosophical Papers*, vol. 2. Oxford: Oxford University Press, 83–132.
——— (1999), "Humean Supervenience Debugged", in *Papers in Metaphysics and Epistemology*. Cambridge: Cambridge University Press, 224–247.
Linde, Andrei (1994), "The Self-Reproducing, Inflationary Universe", *Scientific American* 271 (November): 48–55.
Mackie, John L. (1962), "Counterfactuals and Causal Laws", in R. Butler (ed.), *Analytic Philosophy*. New York: Barnes & Noble, 66–80.
Mellor, David Hugh (1991), *Matters of Metaphysics*. Cambridge: Cambridge University Press.
Nambu, Yoichiro (1985), "Directions in Particle Physics", *Progress in Theoretical Physics* (Supplement) 85: 104–110.
Poincaré, Henri (1963), "The Evolution of Laws", in *Mathematics and Science: Last Essays*. New York: Dover, 1–14.
Pollock, John (1976), *Subjunctive Reasoning*. Dordrecht: Reidel.
Reichenbach, Hans (1954), *Nomological Statements and Admissible Operations*. Dordrecht: North-Holland.
Schweber, Silvan S. (1997), "The Metaphysics of Science at the End of a Heroic Age", in Robert S. Cohen, Michael Horne, and John Stachel (eds.), *Experimental Metaphysics*, Boston Studies in the Philosophy of Science, vol. 193. Dordrecht: Kluwer, 171–198.
Seelau, Eric P., et al. (1995), "Counterfactual Constraints", in Neil J. Roese and James M. Olson (eds.), *What Might Have Been: The Social Psychology of Counterfactual Thinking*. Hillsdale, NJ: Erlbaum, 57–80.
Shoemaker, Sydney (1998), "Causal and Metaphysical Necessity", *Pacific Philosophical Quarterly,* 79: 59–77.
Sider, Theodore (2003), "Reductive Theories of Modality", in Michael J. Loux and Dean W. Zimmerman (eds.), *The Oxford Handbook of Metaphysics*. Oxford: Oxford University Press, 180–208.
Spinoza, Benedict de (1951), *Theological-Political Treatise*. Translated by R. H. M. Elwes. New York: Dover.
Stöltzner, Michael (1995), "Levels of Physical Theories", in Werner DePauli-Schimanovich, Eckehart Köhler, and Friedrich Stadler (eds.), *The Foundational Debate*, Vienna Circle Institute Yearbook, vol. 3. Dordrecht: Kluwer, 47–64.
Strawson, Peter F. (1952), *An Introduction to Logical Theory*. London: Methuen.
Swartz, Norman (1985), *The Concept of Physical Law*. Cambridge: Cambridge University Press.
Thirring, Walter (1995), "Do the Laws of Nature Evolve?", in Michael P. Murphy and Luke A. J. O'Neill (eds.), *What Is Life? The Next Fifty Years*. Cambridge: Cambridge University Press, 131–136.
van Fraassen, Bas (1989), *Laws and Symmetry*. Oxford: Clarendon.
Weinberg, Steven (1977), *The First Three Minutes*. New York: Basic Books.